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THE SENSITIVE EYES OF ANIMALS

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HUMAN TRANSLATION

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THE SENSITIVE EYES OF ANIMALS

DONGWUDE MINYAN

BY: Shuang Xing

SEEING MINUTE THINGS CLEARLY, BUT NOT SEEING THE LARGER THINGS

Frogs hide in the grass and reeds around water, and their bulging eves can see a small insect flying past in an instant, they stick out their tongue and swallow it down. However, if there were knee deep in just killed insects, he would just sit there and die of starvation without opening his mouth. The reason for this is not that he is picky about what he eats, but is that he is not able to see these dead insects. Although the frog has big eyes, they only react to moving objects. He is blind to still objects, even if they are as large as a building.

A frog's eyes only react to two most important things: One is the ability to detect moving objects the size of insects within reach of his tongue - his food. The other is the ability to detect large objects like birds - his enemies. The first signal makes him jump up and eat, and the second signal sends him diving into the water. This is actually due to the simple and effective mechanism which connects his eyes to his brain so he does not just look around in vain, but is able to eliminate all secondary signals and concentrate on those two vital signals - small bugs (food) and large animals (danger).

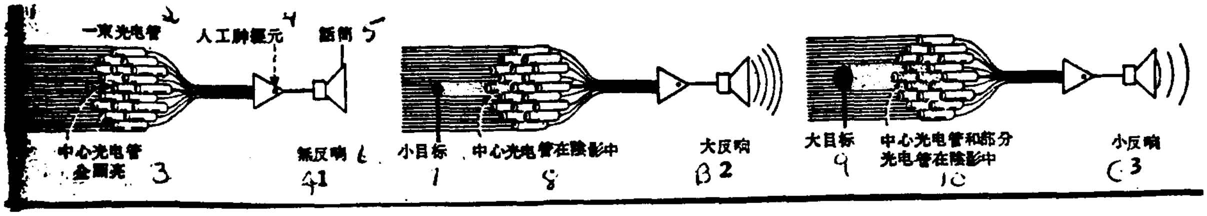

ILLUSTRATION ONE: THIS IS THE DETECTOR DESIGNED IN ACCORDANCE WITH THE CHARACTERISTICS OF A FROG'S EYE. IT IS COMPOSED OF A BUNDLE PHOTOELECTRIC CELLS AND ARTIFICIAL NERVE ELEMENTS. THE CENTRAL PHOTOELECTRIC CELLS ARE CONNECTED TO THE ARTIFICIAL NERVE ELEMENTS WHICH ACT AS INHIBITORS. wHEN LIGHT RAYS SHINE ON ALL THE PHOTOELECTRIC CELLS, THE EXCITATION AND INHIBITION CANCEL EACH OTHER OUT AND NO SIGNAL IS SENT OUT AND THERE IS NO RESPONSE ON THE SPEAKER(1). iF THE CENTRAL PHOTOELECTRIC CELLS ARE BLOCKED FROM THE LIGHT BY A SMALL OBJECT, THEY ELIMINATE THE INHIBITION SIGNAL SENT OUT BY ARTIFICIAL THE NERVE ELEMENTS, AND THE ARTIFICIAL NERVE ELEMENTS ARE "LIT UP" - THEY SEND OUT PULSE SIGNALS. AT THIS TIME, THE STIMULATION IS INCREASED TO MAXIMUM, AND THE SPEAKER PUTS OUT A LOUD SOUND(2). IF THE CENTRAL PHOTOELECTRIC CELLS AND SOME OF THE SURROUNDING CELLS ARE ALL BLOCKED FROM THE LIGHT BY SOME LARGE OBJECT, THE SPEAKER ONLY GIVES OFF A SMALL SOUND.

A. NO RESPONSE. B. LARGE SOUND. C. SMALL SOUND.
1. LIGHT. 2. BUNDLE OF PHOTOELECTRIC CELLS. 3. ALL CENTRAL CELLS ARE EXPOSED TO LIGHT. 4. ARTIFICIAL NERVE ELEMENT. 5. SPEAKER. 6. SMALL TARGET. 7. CENTRAL PHOTOELECTRIC CELLS ARE IN SHADOW. 8. LARGE OBJECT. CENTRAL PHOTOELECTRIC CELLS AND SOME SURROUNDING CELLS ARE IN SHADOW.

Characteristics such as these of the eyes of frog have already been designed into a type of electronic eye (detector, see illustration one). It can only detect a moving target of a certain size, and it will ignore other objects. When it is installed on radar, it can selectively detect and only note the required objects, and all unrelated material is eliminated. It can be used at airfields to watch radar screens, and if it sees an aircraft leave its flight path, it will send out an order to the

aircraft's automatic pilot to correct its course. At stations it can be used to direct traffic into and out of intersections. This type of electronic frog's eye can also be used as automatic tracking for guided missiles.

DETERMINING SPEED WITH A COMPOUND EYE

Praying mantis fly eyes and its brain which is the size of a match head compose a fast positioning instrument. When it first detects a small insect, it immediately transmits to the brain information on the size, flight sped and direction to the brain. Just like computer signals processing in automatic aiming systems, it immediately determines where the small insect will fly to and captures it in a single move. The entire process takes less than one twentieth of a second. The tracking system which we use which weighs more than one ton is not as good as his.

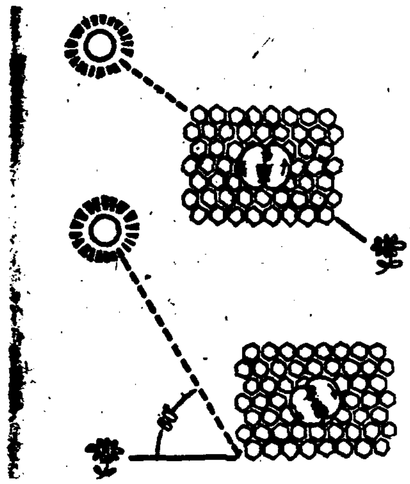

ILLUSTRATION TWO: BEE USE OF SUN FOR DIRECTION FINDING

The compound eyes of the praying mantis and the dragon fly are composed of many thousands of small eyes (see illustration three). Each small eye is a light sensing element. Therefore, the compound eye can capture the images of a series of targets. This is very advantageous for observing moving objects. When the image of one flying insect sequentially enters the individual small eyes, each individual small eye has a different viewing angle, and the image it obtains is slightly different. Based on the images which continue to appear among he small

eyes, he is able to determine the speed of movement of the target. Therefore, the compound eyes of insects are not a simple organ of sight, but are also a special speed measuring instrument. This special structure of insect compound eyes has been thoroughly studied and used to equip tracking systems, and according to the relationship between the time and speed of occurrence of signal (image) at adjacent lenses, it is possible to measure the speed of distant moving objects such as aircraft (see the color illustration).

Based on the capabilities of the small eyes in the compound eyes of a type of beetle (they can measure the speed of a moving object), a type of aircraft ground speed indicator can be constructed. Just like the small eyes, a photo electric cell is mounted at the nose and the tail of the aircraft, and because of the time and angle at which the two photoelectric cells receive the light rays from the surface, it is possible to measure the speed and altitude of the aircraft.

CRAB EYES CAN SEE UNDER WATER

There is a type of crab at the bottom of the ocean which is very good at observing the dark underwater world. His eyes have the ability to enhance differences between targets and their background (light and dark). Because the optic nerves which receive stronger light can eliminate the signals of those optic nerves which receive weaker light, this allows the underwater target appear even clearer. A type of crab eye model utilizing this principle has already been designed and developed. It can enhance the contrast between light and dark, making the television image transmission somewhat clearer for better analysis. If aerial photography and X-ray photography used this sort of crab eye electronic equipment, it would enhance the contrast of the image and would greatly simplify the image analysis process.

THE BEE'S EYES

After the bee has visited the honey source in the field, it flies

back to the hive, making all sorts of gestures to inform the other bees at the hive the distance and location of the honey. Then, swarms of bees will set out to gather the honey. Illustration two shows their tail movement, which is in a figure eight dance along a vertical line with the hive. If the figure eight vertical line is moves up (or down) it indicates that the location of the honey is in the opposite direction (or the same direction) as the sun. If the vertical line portion is at a 60 degree angle left of the sun, it means that the location of the honey is at a 60 degree angle to the left of the sun.

A large number of experiments have demonstrated that bees can determine directions with just a patch of blue sky. The secret to this rare ability is that they can see polarized light.

In the natural light given off by the sun (or a light bulb), the light waves vibrate perpendicular to the direction of the light waves. However, when they are reflected, refracted or scattered, they vibrate mostly in one direction. This is polarized light. The sunlight strikes the minute particles in the atmosphere and is scattered, so a portion of the light from the sky is polarized light. Also, the degree of polarization and direction of polarization of the light from a certain piece of the sky differs in accordance with the relative position of this patch of sky in relation to the sun. Man can mostly not distinguish polarized light. The blue sky which we see, in the eyes of bees, is a pattern of light and dark.

The compound eyes of bees are composed of several thousand small eyes. Each small eye has eight light sensitive cells in a radiating pattern and are connected to nerve fibers. Each small eye is like a polarized light detector and can distinguish polarized light from different directions to determine the location of the sun. They make the inclusive angle between their tail dances and the sun based on the angle between the direction the bees are to set out from the hive and the sun in order to express the direction of the food.

Many insects use the sun as a navigational beacon. However, there are unpredictable clouds in the sky, and once clouds hide the sun, they are lost. This is especially true of bees and ants which are busy gathering food all day long. They only need a patch of blue sky and they can use the polarized light scattered by the clouds for guidance. This is clearly an especially important life skill for these insects.

Based on this direction finding principles of bees, a polarized light celestial compass has been constructed (see color illustration). After polarized light from the sky has passed through a polarized filter it is received by a photoelectric cell. In this manner, even on a cloudy or rainy day, it is possible to determine the direction of travel of an aircraft or ship automatically by the position of the sun.

In the insect world, bees, flies, and scarabs as well as the tianmumaochong (translator's note: phonetic, actual meaning unknown. STC 1131 1612 3029 5722) and the sawfly all rely on polarized light to maintain their stable direction of flight. In the water, the crabs and water fleas are also very sensitive to polarized light. With our technology, we have not yet built an instrument which uses polarized light underwater.

The color illustration is of various direction finding and navigation methods used by insects and by human technology. Of these, the use of sound waves and gyroscopes were discussed in the previous issue. The use of infrared rays, polarized light, compound eyes, smell are discussed in various articles in this issue.

The use of electronic waves: Man can only use electrical waves in the air for radar and radio direction finding instruments, while animals only use electrical waves in the water. The illustration is the snout fish of the Nile River searching for food with its snout buried in the mud. It has its tail high in the water which continuously transmits electrical pulses, and if an enemy approaches, the return waves are received by the base of the dorsal fin and the fish immediately flees.

The use of the earth's magnetic field: Some researchers believe that when birds (such as pigeons) are making long distance flights they can follow the lines of the earth's magnetic field because membranes in their eyes can detect change in the earth's magnetic field.

Use of starlight: More and more materials demonstrates that birds on long distance flights can possibly use the location of the sun and stars to determine their geographical coordinates. This type of celestial guidance is already used in long range rockets.

图3 昆虫的复眼往往是由几百、几千个小眼組成。右图是复眼的結构。左图是通过复眼拍攝一幅人像所得到的照片(局部)。

ILLUSTRATION THREE: INSECT COMPOUND EYES ARE USUALLY COMPOSED OF HUNDREDS OR THOUSANDS OF SMALL EYES. RIGHT IS STRUCTURE OF COMPOUND EYE. LEFT IS A PICTURE OF A HUMAN FACE THROUGH A COMPOUND EYE.

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